Chapter 1: Introduction

From 1984 through 1988, the U.S. Environmental Protection Agency (EPA) and the Pennsylvania Department of Environmental Resources (PA DER, now PA DEP) studied the water quality of long-term pre-existing discharges from abandoned mine lands throughout Pennsylvania as part of a cooperative project on remining. Water quality data from these discharges were examined using univariate, bivariate, and time series statistical analyses to assess coal mine drainage discharge behavior. The results of the statistical analyses were included in a series of eight unpublished reports prepared for PA DEP and EPA by Dr. J. C. Griffiths of the Pennsylvania State University in 1987 and 1988.

This report presents a compilation of the work by Dr. Griffiths and co-authors and was prepared by PA DEP and EPA, to support proposal of the Coal Remining Subcategory under existing Coal Mining industry regulations (40 CFR part 434). This report specifically supports statistical procedures provided in EPA's *Coal Remining Statistical Support Document* (EPA-B-001-001), and is intended to be a companion to that document. Chapter 1 of the *Coal Remining Statistical Support Document* contains a description of the remining program history in Pennsylvania from 1984 to 1999, including the development of the REMINE computer program and permitting procedures used in issuing approximately 300 remining permits during that time period. Chapter 1 of the Statistical Support Document also contains the results of an evaluation of state remining programs in 20 states that was completed by the Interstate Mining Compact Commission (IMCC).

Several publications described and documented the mining engineering and treatment costing components of the original cooperative remining project of EPA and PA DER (listed and briefly described in Chapter 1 of the *Coal Remining Statistical Support Document*), but the statistical work of Dr. J.C. Griffiths and co-authors was not published or widely disseminated, and John C. Griffiths died at age 82 in June, 1992. This report was compiled, edited and completed by his co-authors and DynCorp, I & ET. J.C. Griffiths is listed as the major author posthumously because this document contains his original work and is a tribute to him and his work.

There are several additional correlations between this report and the *Coal Remining Statistical Support Document*.

- Chapter 2 of the *Coal Remining Statistical Support Document* contains descriptions of the three fundamental acid mine drainage discharge types and their respective behaviors (flow and water quality relationships) that are based on work done in the statistical studies of the Arnot, Ernest, and Markson discharges featured in Chapters 4, 6, and 8 of this report.
- Chapter 5 of the *Coal Remining Statistical Support Document* includes numerous figures and tables depicting various options in baseline pollution load development (e.g., Table 5.1a) that are based upon the data sets in Chapters 4 through 8 and Appendices A through F of this report.
- Chapter 5 of the *Coal Remining Statistical Support Document* contains additional data from 1988 to 1999 of the Fisher and Markson sites, providing excellent additional information on the long term variations in these discharges.

The establishment of the baseline pollution load for a coal remining permit requires the proper sampling and chemical analysis of the abandoned mine drainage discharges, and the appropriate statistical analysis of the flow, water quality and pollution load data. The term proper sampling in this report, is taken in two contexts: (1) following the recommended procedures for collection of surface- and ground-water samples, (including measurements of flow and water quality parameters, and fixing, storing and transporting the samples to the laboratory for chemical analyses), and (2) collecting a sufficient number of samples over an adequate duration and sampling interval in order to be representative of the variations in flow and water quality of the discharges throughout the year.

Guidelines and protocols for water sample collection from EPA, the U.S. Geological Survey (USGS), and other sources, are compiled in Table 9.1. These 14 manuals and related publications represent some of the most recent technical guidance disseminated by Federal agencies on water sampling. Much of this information is founded on common sense and earlier publications on this subject, and include for example, recommendations, sampling streams and major mine discharges at approximately mid-stream and mid-depth to avoid unrepresentative effects of surface debris, bottom sediments, chemical stratification or lack of mixing near stream banks. Water sampling procedures are as important as the laboratory analysis and the statistical analysis of the discharge data. If the water sampling procedures are flawed or unrepresentative, the laboratory analyses, regardless of its high degree of accuracy and precision, may be meaningless. Similarly, the most rigorous statistical analysis may be worthless if it is based upon faulty laboratory analyses or flawed sampling procedures.

The statistical aspects of proper sampling are summarized in Chapter 9 of this report and are discussed in numerous other references including Griffiths (1967) and Griffiths and Ondrick (1968) concerning the proper sampling of geologic populations. In statistical analyses, it is always important to work with samples that are representative of the population from which they are drawn (see Chapter 2 of this report). Since most of the abandoned mine discharges included in this report flow continuously, there is an almost infinite number of samples that could be drawn throughout the water year. For example, one sample collected every hour equals 720 samples per month or 8,760 samples per year. Representative sample collection should be assessed in regards to practicality, feasibility, and cost.

Chapter 2 of this report provides an introduction to the statistical methods that may be employed in establishing baseline pollution load, and Chapter 3 describes the data analysis algorithm that was developed for evaluating mine drainage discharges (see Figure 1.2a of the *Coal Remining Statistical Support Document* and Figure 3.1 of this report). Abandoned mine drainage discharge data from six sites in Pennsylvania are statistically analyzed and presented in graphs and tables in Chapters 4 through 8 and Appendixes A through F of this report. The locations of these sites are shown in Figure 1.1. More detailed site maps and descriptions of the site characteristics are included in the beginning of each chapter. Chapter 9 is a summary of the statistical analyses presented throughout this report, with emphasis on the interpretations of time series analysis and quality control limits.

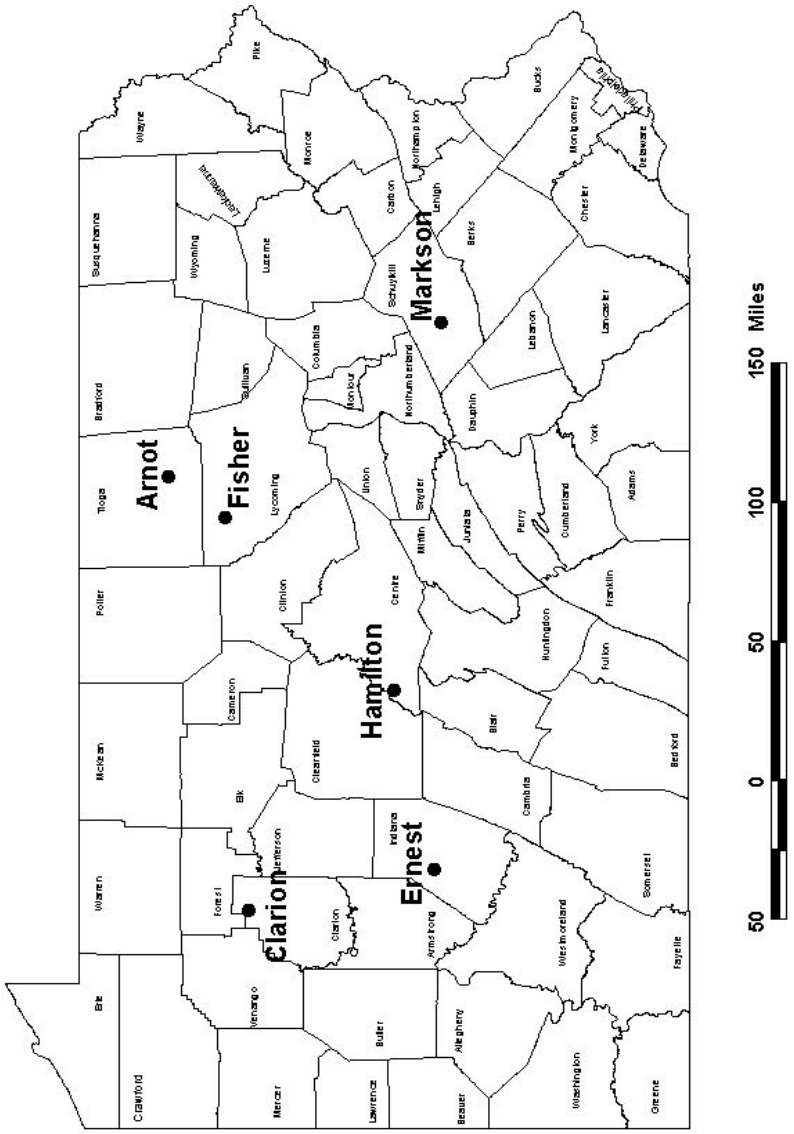

Figure 1.1: Map of Pennsylvania Counties and Mine Sites